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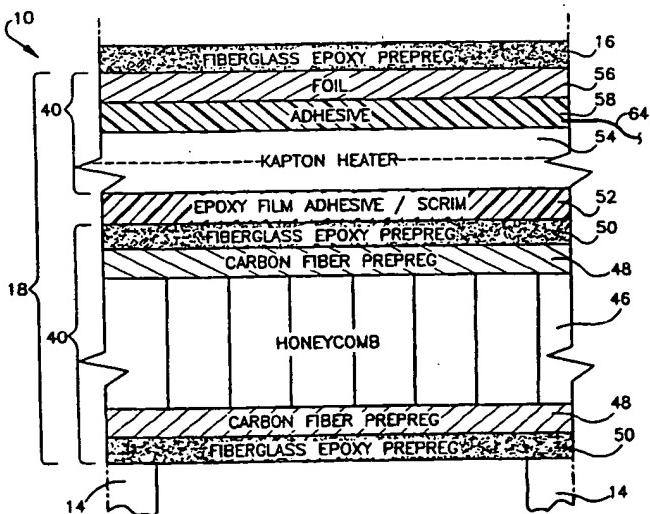
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- (71) Applicant: BFGOODRICH COMPANY [US/US]; 4 Coliseum Centre, 2730 W. Tyvola Road, Charlotte, NC 28217-4578 (US).
- (72) Inventors: GIAMATI, Michael, J.; 2479 Maylo Path, Akron, OH 44312 (US). SCHRAMM, Kevin, C.; 14066 Whitney Road, Strongsville, OH 44136 (US).
- (74) Agent: MURPHY, Cynthia, S.; Renner, Otto, Boisselle & Sklar, LLP, 1621 Euclid Avenue, 19th Floor, Cleveland, OH 44115 (US).
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(54) Title: AIRCRAFT HEATED FLOOR PANEL



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(57) Abstract: An aircraft heated floor panel (10/110/210) including a support level (40/140/142), a heater level (42/142/242) and a protective cover layer (16/116/216). The support level and the heater level are formed as a composite structure (18/118/218), such as by curing a series of layers together to form the structure. A thermal conductor (62) may be provided to more evenly distribute a generated heat pattern. Alternatively, a metal sheet (116/216) may be used for the cover layer which performs a heat distributing function. If a metal sheet (216) is used, an elastic-after-bonding adhesive (266) may be used to secure the metal sheet (216) to the heater level (242) to accommodate different rates of thermal expansion.

AIRCRAFT HEATED FLOOR PANEL

This invention relates generally to an aircraft heater floor panel and to methods for making the same.

BACKGROUND OF INVENTION

An aircraft will commonly include a heating system in order to maintain the cabin at a comfortable temperature during flight. The floor of the aircraft is a particular area of concern whereby heater floor panels often are part of an aircraft's heating system. An aircraft heater floor panel typically comprises an electric heater element which heats up when a current is applied by a controller through supply lines. The heater element can comprise resistance wire or an etched foil path arranged in a zig-zag pattern within a dielectric layer of the floor panel.

An aircraft heated floor panel will generally comprise a lower support level, an upper heater level, and a top layer. The lower layer is supported by structural members of the aircraft and has a structural integrity sufficient to support people and objects resting thereon. The upper level incorporates the heating element and thus includes a heat generating layer. Conventionally, the lower support level and the upper heater level have each been built as separate subassemblies in distinct manufacturing processes. The support level is secured to the aircraft members and then the separately assembled heater level is placed on top of the support panel and then fastened thereto with a fastener, such as a countersunk screw.

The top layer protects the underlying heater level against floor-traffic related damage (e.g., punctures from high heels, chips from dropped objects, scratches from dragged luggage, etc.). It is often desirable to have the top layer also function as a heat distributing layer and, to this end, the top layer can comprise a metal sheet, such as an aluminum sheet. However, such metal sheets generally have a different rate of thermal expansion than the underlying layers whereby warping of the metal layer can occur during heating and cooling of the panel.

SUMMARY OF THE INVENTION

The present invention provides an aircraft heated floor panel wherein the support level and the heater level form a composite structure. To make the floor panel, a plurality of curable layers are compiled together to form the support level and the heater level, and the compiled layers are cured to form the composite structure. Thus,

the support level and the heater level do not each need to be made separately as a subassembly and then later assembled together to form the panel.

The present invention also provides an aircraft heated floor panel including a heat distribution layer which includes a thermal conductor for distributing a heat pattern generated by a heat generation layer. The thermal conductor is designed to accommodate heat expansion whereby warping problems are minimized. With such a thermal conductor, the protective cover layer of the floor panel need not function as a heat distributor whereby it may be made of a material such as fiberglass.

The present invention further provides an aircraft heater floor panel wherein the protective cover layer is secured to the heater level with an adhesive which retains elasticity after bonding, such as a pressure sensitive adhesive. When an aluminum material is used for the cover layer, this type of adhesive allows such a metal face sheet to expand and contract at a different thermal expansion rate than the support/heater layers. Thus, the protective cover layer can be cured at the same time as the support/heater layers and can also function as a heat distributor.

DRAWINGS

Figure 1 is a schematic perspective view of an aircraft floor panel 10 according to the present invention installed in an aircraft.

Figure 2 is a schematic diagram of a heating system according to the present invention, the system including the aircraft panel 10.

Figure 3 is a cross-sectional view of a heat generation layer of the floor panel in accordance with the present invention as seen along lines 3-3 of Figure 2.

Figure 4 is a cross-sectional view of the aircraft floor panel 10.

Figure 5 is a top view of a thermal conductor for the floor panel 10.

Figure 6 is a top view of another thermal conductor for the floor panel 10.

Figure 7 is a cross-sectional view of an aircraft panel 110 according to the present invention.

Figure 8 is a cross sectional view of an aircraft panel 210 according to the present invention.

Figures 9A - 9F are schematic views of a method of making the aircraft floor panel 210 according to the present invention.

DETAILED DESCRIPTION

Referring now to the drawings, and initially to Figure 1, a heated aircraft floor panel 10 according to the present invention is shown installed in an aircraft 12. The floor panel 10 is provided in order to maintain the aircraft cabin at a comfortable temperature and is supported around its perimeter by aircraft structure 14. As is explained in more detail below, the floor panel 10 comprises a plurality of layers forming a composite structure 18 and a top layer 16 mounted thereon. The layer 16 protects the underlying structure 18 against floor-traffic related damage (e.g., punctures from high heels, chips from dropped objects, scratches from dragged luggage, etc.).

As is shown schematically in Figure 2, the floor panel 10 is part of the aircraft's heater system 20 and includes an electrical heater element 22 which heats up when a current is applied by a controller 24 via lines 26 and 28. In the illustrated embodiment, the electric heater element 22 is configured in a zig-zag heat distributing pattern and is encapsulated in a dielectric material 30. The element 22 may be an etched foil type element or a resistance wire element and/or the element may be configured in any other pattern which will distribute generated heat over a large area. Other types of heaters are also possible with and contemplated by the present invention. For example, the heater element 22 could instead be a thermal unit wherein a heated fluid (e.g., water, air, etc.) circulates through lines 26 and 28.

Referring now additionally to Figure 3, the heated aircraft floor panel 10 is shown in detail. The composite structure 18 of the illustrated floor panel 10 comprises a lower support level 40 and an upper heater level 42. The protective layer 16 is mounted on top of the heater level 42 and is made of a protective material (e.g., a fiberglass epoxy prepreg) to improve durability.

The illustrated support level 40 comprises a honeycomb layer 46 sandwiched between first fiber layers 48 and further sandwiched between second fiber layers 50. A suitable honeycomb material is ECA-1/8-7.7(3)-.285 ThK, hexagonal of polyamide paper, phenolic resin bonded, cured, heavy, floor quality, available from Euro-Composites System, although other honeycomb and non-honeycomb materials may also be suitable. The first fiber layers 48 may be formed of carbon fiber prepreg and the second fiber layers 50 may be formed of fiberglass epoxy prepreg. A prepreg is a fiber reinforced polymer composite layer formed of a plurality of filamentary materials in

a matrix of thermoset polymeric material. Such materials and their combination into a laminate composite structure are well known in the art.

Other high modulus or high strength fibers such as aramid and the like may be employed alone or in combination with these and other fiber types. In addition to epoxy, other thermoset polymeric materials, such as phenolic, may be employed in these prepgs alone or in combination. Selection of particular materials and a particular construction are predicated upon a number of factors which may include stiffness, overall thickness limitations, and overall weight limitations. Additional and different support layers which provide sufficient stiffness, satisfy thickness limitations and accommodate weight considerations may be used.

An adhesive layer 52 is provided between the support level 40 and the heater level 42 so that the final assembly forms an integral unit or structure. The adhesive may be a film adhesive (e.g., epoxy) and should be capable of withstanding elevated curing temperatures so that during the curing process the adhesive layer 52 provides a good bond between the support level 40 and the heater level 42. A preferable adhesive for layer 52 is an epoxy film adhesive such as PL777 available from Sovereign Engineered Adhesives, L.L.C. However, other adhesives which are compatible for bonding and co-cure with the adjacent layers also are acceptable. The adhesive layer 52 may incorporate a scrim if necessary or desired for better distribution of the adhesive. An example of a suitable scrim material is Reemay 2250.

The heater level 42 includes a heat generation layer 54 which includes the electric heater element 22 encapsulated in the dielectric material 30 (Figures 2 and 3). The element 22 may be isolated by encapsulation in the material 30 by disposing it between plies of an appropriate curable material such as thermoset plastic or any other dielectric or electrically non-conductive material. Suitable dielectrics are well known in the art, and may include such materials as polyamide, epoxies, or other films and plastics, such as Mylar. For example, the plies may be made of a polyamide film, such as Kapton® available from E.I. Dupont DeNeumours Co.

The heater level 42 also includes a heat distribution layer 56 mounted on the heat generation layer 54 with an adhesive layer 58. The heat distribution layer 56 promotes heat transfer into the gaps between the zig-zag lines of the heat distributing pattern of the heater element 22. More particularly, the heat distribution layer 56

spreads the heat from the heat element 22 two-dimensionally across the surface of the floor panel 10 to provide a substantially uniform and homogenous heat distribution pattern. Thus, the heat distribution layer 56 minimizes or eliminates hot and cold spots from occurring on the surface of the floor panel 10 during both the transient mode (e.g., heat-up) and steady state operation of the aircraft's heating system 20 (Figure 2).

The heat distribution layer 56 includes a thermal conductor 62 (Figures 5 and 6) encapsulated in an adhesive. The thermal conductor 62 can be any of a number of materials which are thermally conductive and, preferably, both electrically and thermally conductive so that the heat distribution layer 56 can additionally serve as a grounding plate and as an EMI shield when a grounding lead 64 (Figure 4) is connected thereto. A variety of adhesives can be used to encapsulate the thermal conductor 62, provided that they are compatible with the adjacent layers of the heater panel 10. Resins such as polyester, BMI, and phenolics are suitable and film adhesives such as epoxies are also suitable.

The thermal conductor 62 shown in Figure 5 is an expanded, perforated metal foil, that is a metal foil in which perforations are formed and then slightly expanded to elongate and provide each perforation hole with a greater area. Alternatively, the thermal conductor can be a perforated foil which has not been expanded. Metals such as aluminum and copper are suitable for use for the foil. A suitable expanded metal foil is Astrostrike, AL060, available from Astroseal Products Manufacturing Co., Inc.

Another thermal conductor 62 is shown in Figure 6, this conductor 62 comprising a conductive screen formed from a plurality of conductive fibers which are interwoven, overlapped and/or otherwise arranged in a mesh pattern. The fibers can be conductive metal wires or, alternatively the fibers may be a nonmetal material which is metal coated or metallized, such as a metallized fiberglass. Graphite fabrics and the like may also be used.

The thermal conductor 62 can be any of a number of materials which are thermally conductive and, preferably, both electrically and thermally conductive so that heat distribution layer 56 can provide heat distribution, grounding, and EMI shielding. Additionally or alternatively, the thermal conductor 62 has holes or perforations to promote encapsulation within adjacent plastic, adhesive or composite layers because of the flow of the curable materials through the holes during the curing process. This

helps to promote lamination, and/or prevent de-lamination, of the heater panel 10. Heat distribution is believed to be optimized when the conductor has an approximately forty-five percent to approximately sixty-one percent open area.

Although thermal conductors of various constructions are possible with and contemplated by the present invention, it may be noted that expanded metal foils provide additional benefits, such as being light weight (when compared to, for example, solid metals). Also, expanded metal foil tends to easily conform to three dimensional shapes thereby eliminating, or at least minimizing, warping in the final heater panel 10. Furthermore, the curing of the metal foil 62 within the heat distribution layer 56 can be done at the same time as curing the other heater layers thereby eliminating the need for a secondary cure.

To manufacture the heated floor panel 10, the heat generation layer 54 can be preassembled so that it can be tested to assure an acceptable operation range. The layer 54 and the uncured layers 46, 48, 50, 52, 54, 56, and 58 are lay up on a flat cure plate in the sequence shown in Figure 3. Once the panel lay up is completed, the lay up is vacuum bagged and cured in an autoclave. Curing can also be accomplished in a heated press or any other means for applying heat and pressure to the panel assembly. Once the panel assembly is cured, any necessary post-cure steps (final trim, mounting hole drilling, painting, etc.) can be performed. The fiberglass prepreg cover layer 16 may then be mounted on top of the heat distribution layer 56.

The present invention allows a wet lay to be used in the manufacture of the panel 10. A wet lay up is a fiber reinforced polymer composite which cures at room temperature and/or at room atmospheric pressure. A composite is a matrix of dissimilar material layers, where one of such layers generally includes a curable plastic reinforced with a fibrous material.

As noted above, the thermal conductor 62 of the heat distribution layer 56 preferably has holes or perforations and is encapsulated in resin. During the cure process, the resin in adjacent layers flows through and around the holes of the metal foil or screen of the heat distribution layer 56, thereby improving the bond between the thermal conductor 62 and adjacent materials. Furthermore, as also noted above, the perforations or holes in the thermal conductor minimize or eliminate thermal expansion problems during the curing process.

Referring now Figure 7, another heated floor panel 110 according to the present invention is shown in detail. The illustrated floor panel 110 has a lower support level 140, an upper heater level 142, and its protective layer 116 is mounted on top of the heater level 142. The lower support level 140 can be essentially the same as the support level 40 of the floor panel 10 and include a honeycomb layer 146 sandwiched between first fiber layers 148 and further sandwiched between second fiber layers 150.

The upper heater level 142 comprises a heat generation layer 154 which can be essentially the same as the heat generational layer 54 of the floor panel 10 and thus includes the electric heater element 22 encapsulated in the dielectric material 30 (Figures 2 and 3). An adhesive layer 152, which can be essentially the same as the adhesive layer 52, is provided between the support level 140 and the heater level 142.

The heater level 142 of the panel 110 does not include a separate heat distribution layer. Instead, the top layer 116 serves as both a heat distribution layer and a protective layer. To this end, the protective layer 116 is made of a material having suitable thermal conduction properties for heat distribution while at the same time be able to withstand weight, damage, and wear associated with floor-related traffic. The top layer 116 is preferably made of a metal, such as aluminum, titanium, steel or stainless steel. Although the perforated foils and/or screens used for the thermal conductor 62 of the panel 10 could be used for the layer 116, in most instances a solid metal layer will be preferred (despite its increased weight) for improved damage and wear resistance.

An adhesive layer 166 bonds the metal sheet layer 116 to the heater level 142 and a scrim layer 168 may also be provided between the layers 116 and 166. The adhesive layer 166 is comprised of an adhesive which is suitable for bonding adjacent layers together, such as EA9395 available from Hysol Aerospace Adhesives.

Manufacture of the heater panel 110 is similar to the manufacture of the heater panel 10, with the top layer 116 being bonded to the other panel layers in a secondary operation. Specifically, after the composite structure of the support level 140 and the heater level 142 have been assembled, cured, and cooled to room temperature, the adhesive 166 is used to the secure the sheet metal layer 116 to the top of the heater generation layer 154. The secured sheet metal layer 116 can then be cut/trimmed to the correct size and an appropriate surface treatment (e.g., paint, primer, anodizing,

etc.) may be applied.

Referring now to Figure 8, another heated floor panel 210 according to the present invention is shown in detail. The illustrated floor panel 210 has a composite structure 218, including a lower support level 240 and an upper heater level 242, with its protective layer 216 being mounted on top of the heater level 242. The lower support level 240 can be essentially the same as the support level 40/140 of the floor panel 10/110 and includes a honeycomb layer 246 sandwiched between first fiber layers 248 and further sandwiched between second fiber layers 250.

The upper heater level 242 comprises a heat generation layer 254 which can be essentially the same as the heat generational layer 54/154 of the floor panel 10/110 and thus includes the electric heater element 22 encapsulated in the dielectric material 30 (Figures 2 and 3). An adhesive layer 252, which can be essentially the same as the adhesive layer 52/152, is provided between the support level 240 and the heater level 242.

The heater level 242 of the panel 210, like the heater level 142 of the panel 110, does not include a separate heat distribution layer and instead its top layer 216 serves as both a heat distribution layer and a protective layer. The top layer 216 is preferably a metal face sheet, and more preferably an aluminum sheet.

An adhesive layer 266 bonds the top layer 216 to the composite structure 218. According to this embodiment of the invention, the adhesive layer 266 is an adhesive which retains elasticity after bonding, specifically a pressure sensitive adhesive (PSA) which is activated by the application of pressure and which performs appropriately during elevated curing temperatures. Suitable pressure sensitive adhesives include acrylic pressure sensitive adhesives (e.g., catalog number F-9473PC available from Minnesota Mining and Manufacturing Company, St. Paul, Minnesota, USA.) Primers may be used to enhance the bonding characteristics of the adhesive.

The design of the floor panel 210 eliminates the need for a separate bonding step for the metal face sheet 216 and/or the need to perform this step at room temperature. With the floor panel 110, for example, this is not possible due to the differences in the thermal expansion rates between the support/heater layers and the metal layer. Specifically, at the high temperatures necessary to cure the support/heater layers, the metal face sheet would expand outwardly at a greater rate

than the support/heater layers. If a high temperature film adhesive was used to secure the metal face sheet to the underlying support/heater layers, such an adhesive would lock the metal face sheet in this expanded condition. As the panel was subsequently cooled to room temperature, the bonded metal face sheet would attempt to contract inwardly thereby causing gross warping of the sheet.

A method of making the floor panel 210 according to the present invention is schematically shown in Figures 9A-9F. Initially, the layers 218 of the lower support level 240 and the upper heater level 242 are compiled. (Figure 9A.) The pressure sensitive adhesive layer 266 is then applied to the top surface (Figure 9B) and the metal sheet layer 216 is placed on top of the adhesive layer 266 (Figure 9C). The support/heater layers 218 are then subjected to a curing process at an elevated temperature (e.g., in excess of about 250° F) and, at the same time, pressure may be applied to activate the pressure sensitive adhesive layer 266. (Figure 9D.) During the heat curing, the metal sheet layer 216 expands outwardly due to the differences in the thermal expansion rates between the support/heater layers 218 and the metal sheet 216. (Figure 9E.) As the panel 210 is subsequently cooled to room temperature (e.g., heat is removed and the panel is allowed to cool), the bonded metal face sheet 216 contracts inwardly. (Figure 9F.)

Because pressure sensitive adhesives retain elasticity after bonding, the metal sheet layer 216 is allowed to contract inwardly without warping as the panel 210 is cooled to room temperature. Additionally, the thickness of the pressure sensitive adhesive layer 266 may be varied to accommodate different curing temperatures. Generally, the greater the thickness, the higher curing temperature that may be used. For example, a thickness of 0.010 inch would correspond to a curing temperature of about 280°F.

Additional manufacturing steps can be streamlined as well. For example, the metal sheet layer 216 can be cut to a net shape and treated with the appropriate surface treatment and then bonded to the other layers 218 in one step.

CLAIMS

1. An aircraft heated floor panel (10/110/210) comprising:
 - a support level (40/140/240) for supporting the panel on structural members (14) of the aircraft (12);
 - a heater level (42/142/242) positioned above the support level for generating heat; and
 - a protective cover layer (16/116/216) positioned above the heater level to protect the underlying levels from floor-related damage;
 - the panel being characterized by the support level (40/140/240) and the heater level (42/142/242) forming a composite structure (18/118/218).
2. An aircraft heated floor panel (10/110/210) as set forth in the preceding claim wherein the support level (40/140/242) and the heater level (42/142/242) comprise a series of layers cured together to form the composite structure (18/118/218).
3. An aircraft heated floor panel (10) as set forth in either of the two preceding claims wherein the heater level (42) comprises a heat generating layer (54) which generates a heat pattern and a heat distributing layer (56) which distributes the heat.
4. An aircraft heated floor panel (10) as set forth in any of the preceding claims wherein the heat distributing layer (56) comprises a thermal conductor (62).
5. An aircraft heated floor panel (10) comprising a heat generation layer (54) which generates a heat pattern and a heat distributing layer (56) which includes a thermal conductor (62) for distributing the heat pattern.
6. An aircraft heated floor panel (10) as set forth in either of the two preceding claims wherein the thermal conductor (62) is made from aluminum, copper, graphite, and/or metallized fibers.

7. An aircraft heated floor panel (10) as set forth in the preceding claim wherein the thermal conductor (62) comprises a metal foil.

8. An aircraft heated floor panel (10) as set forth in the preceding claim wherein the thermal conductor (62) comprises a perforated metal foil.

9. An aircraft heated floor panel (10) as set forth in the preceding claim wherein the thermal conductor (62) comprises an expanded perforated metal foil.

10. An aircraft heated floor panel (10) as set forth in any of claims 4-6, wherein the thermal conductor (62) includes a conductive mesh.

11. An aircraft heated floor panel (10) as set forth in any of the claims 4-10 wherein the thermal conductor (62) comprises a plurality of openings forming an open area.

12. An aircraft heated floor panel (10) as set forth in the preceding claim wherein the thermal conductor (62) has approximately forty-five percent to approximately sixty-one percent open area.

13. An aircraft heated floor panel (10) as set forth in any of claims 3-12 wherein the heat distribution layer (56) is bonded to the heat generation layer (54) with an adhesive (58).

14. An aircraft heated floor panel (10) as set forth in the preceding claim wherein the adhesive (58) is a high temperature curing adhesive.

15. An aircraft heated floor panel (10) as set forth in any of claims 3-14 wherein the heat distribution layer (56) and the heat generation layer (54) are co-cured together.

16. An aircraft heated floor panel (10) as set forth in any of claims 4-15, further comprising an electrical grounding lead (64) connected to the thermal conductor (62).

17. An aircraft heated floor panel (10) as set forth in any of the preceding claims wherein the protective cover layer (16) comprises a fiberglass prepreg layer.

18. An aircraft heated floor panel (110/210) as set forth in either of claims 1 or 2, wherein the protective cover layer (116/216) comprises a metal face sheet.

19. An aircraft heated floor panel (110/210) as set forth in the preceding claim wherein the metal face sheet (116/216) is made of aluminum, titanium, steel, or stainless steel.

20. An aircraft heated floor panel (110/210) as set forth in the preceding claim wherein the protective cover layer (116/216) comprises an aluminum face sheet secured to the heater level (142/242) with an adhesive (166/266).

21. An aircraft heated floor panel (210) as set forth in any of claims 18-20, wherein the adhesive (266) is an elastically bonding adhesive.

22. An aircraft heated floor panel (210) comprising:
a support level (240) for supporting the panel on structural members (14) of the aircraft (12);
a heater level (242) positioned above the support level for generating heat; and
a protective cover layer (216) positioned above the heater level to protect the underlying levels from floor-related damage;
the panel being characterized by the protective cover layer (216) being secured to the heater level (242) with an elastically bonding adhesive (266).

23. An aircraft heated floor panel (210) as set forth in the preceding claim, wherein the elastically bonding adhesive (266) is a pressure sensitive adhesive.

24. An aircraft heated floor panel (210) as set forth in the preceding claim, wherein the pressure sensitive adhesive (266) is an acrylic pressure sensitive adhesive.

25. An aircraft heated floor panel (10/110/210) as set forth in any of the preceding claims wherein the support level comprises includes a honeycomb layer sandwiched between fiber layers.

26. An aircraft heated floor panel (10/110/210) as set forth in any of the preceding claims, wherein the heater level (42/142/242) comprises a resistive element (22) encapsulated in cured thermoset plastic plies.

27. An aircraft heated floor panel (10/110/210) as set forth in any of the preceding claims, further comprising a high temperature curing adhesive layer (52/152/242) between the support level (40/140/240) and the heater level (42/142/242).

28. In combination, an aircraft (12) and an aircraft heated floor panel (10/110/210) as set forth in any of the preceding claims.

29. A method of making the aircraft heated floor panel of any of the preceding claims, said method comprising the steps of:

compiling a plurality of curable layers together to form the support level and the heater level;

curing the compiled layers to form the composite structure.

30. A method as set forth in the preceding claim when they depend from either of claims 4 or 5, wherein said compiling step comprises applying an adhesive to the heat generation layer and disposing the heat distribution layer on the adhesive; and wherein said curing step comprises curing the heat generation and heat distribution layers at an elevated curing temperature.

31. A method of making an aircraft heated floor panel, comprising the steps of:

compiling a plurality of curable layers together to form a support level and a heater level;

curing the compiled layers to form a composite structure.

32. A method as set forth in either of the preceding claims wherein said curing step is performed at an elevated curing temperature.

33. A method as set forth in the preceding claim further comprising the step of securing the protective cover sheet to the heater level with an adhesive.

34. A method as set forth in the preceding claim wherein said securing step is performed in a secondary operation.

35. A method as set forth in claim 33 wherein said securing step comprises applying a layer of an elastic-after-bonding adhesive to the top of the heater level and placing the protective cover layer on top of the adhesive layer prior to the curing step and wherein said curing step comprises curing the support/heater layers and the protective cover layer together.

36. A method as set forth in the preceding claim wherein the protective cover layer is a metal sheet and wherein the elastic-after bonding adhesive allows the metal face sheet to expand and contract at a different thermal expansion rate than the support/heater layers during the curing step and subsequent cooling.

37. A method of making an aircraft heated panel as set forth in any of claims 21-28 comprising the steps of:

applying a layer of the pressure sensitive adhesive to the top of the heater level,
placing the metal face sheet on top of the adhesive layer,
curing the support/heater layers and the metal face sheet at an elevated curing temperature, and

cooling the cured layers and the metal face sheet to an ambient temperature; wherein the pressure sensitive adhesive layer allows the metal face sheet to expand and contract at a different thermal expansion rate than the support/heater layers during the curing and cooling steps.

38. A method of making an aircraft floor panel, said method comprising the steps of:

compiling a plurality of curable layers together to form a lower support level and an upper heater level,

applying a layer of a pressure sensitive adhesive to the top of the structure,
placing a metal face sheet on top of the pressure sensitive adhesive layer,
curing the support/heater layers, the pressure sensitive adhesive layer, and the metal face sheet at an elevated curing temperature, and
cooling the cured layers and the metal face sheet to an ambient temperature; wherein the pressure sensitive adhesive layer allows the metal face sheet to expand and contract at a different thermal expansion rate than the support/heater layers during the curing and cooling steps.

39. A method as forth in either of the two preceding claims, wherein the curing temperature is at least about 250° F.

40. A method as set forth in the preceding claim, wherein the layer of the pressure sensitive adhesive is about 0.010 inch and wherein the curing temperature is about 260° F.

41. A method as set forth in any of the preceding three claims, wherein the face sheet is cut to net shape prior to the curing step.

42. A method as set forth in any of the preceding four claims, wherein a surface treatment is applied to the face sheet prior to the curing step.

43. A heating device comprising a support (40/140/240) and a heater (42/142/242) forming a composite structure (18/118/218).

44. A heating device including a thermal conductor (62) for distributing a heat pattern and a protective cover (16) positioned above the thermal conductor.

45. A heating device comprising a cover (216) secured to a heater (242) with an elastically bonding adhesive (266).

46. A method of making a heating device comprising the step of forming a support and a heater as a composite structure.

47. A method of making a heating device comprising the step of securing a protective cover to a heater with an adhesive which retains its elasticity after bonding to accommodate different thermal expansion rates.

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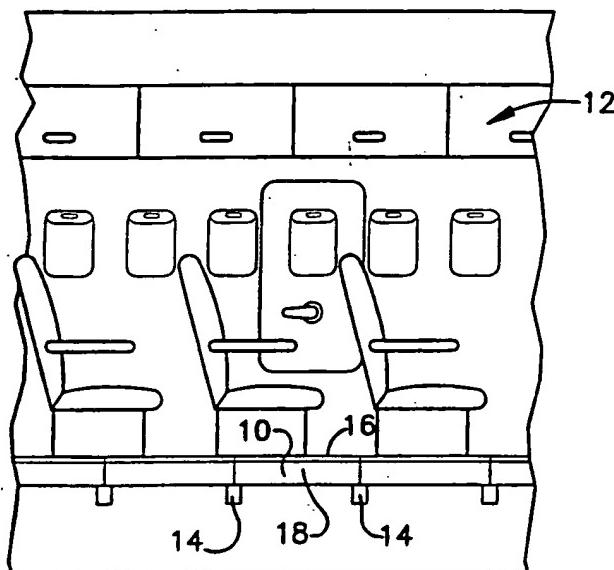


FIGURE 1

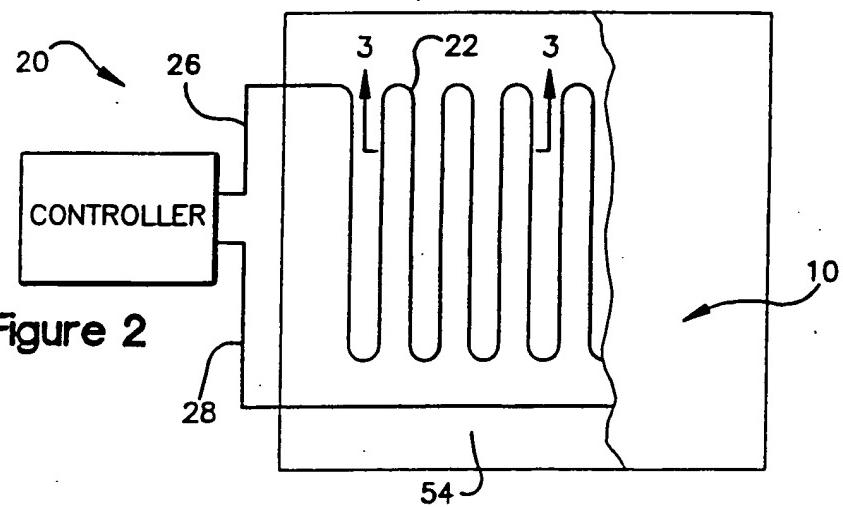


Figure 2

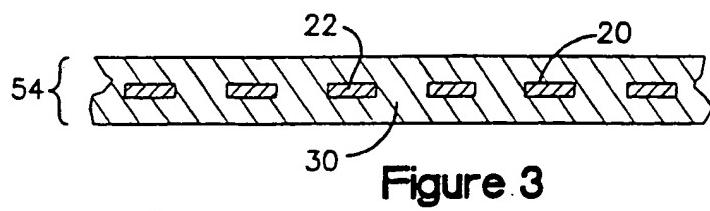


Figure 3

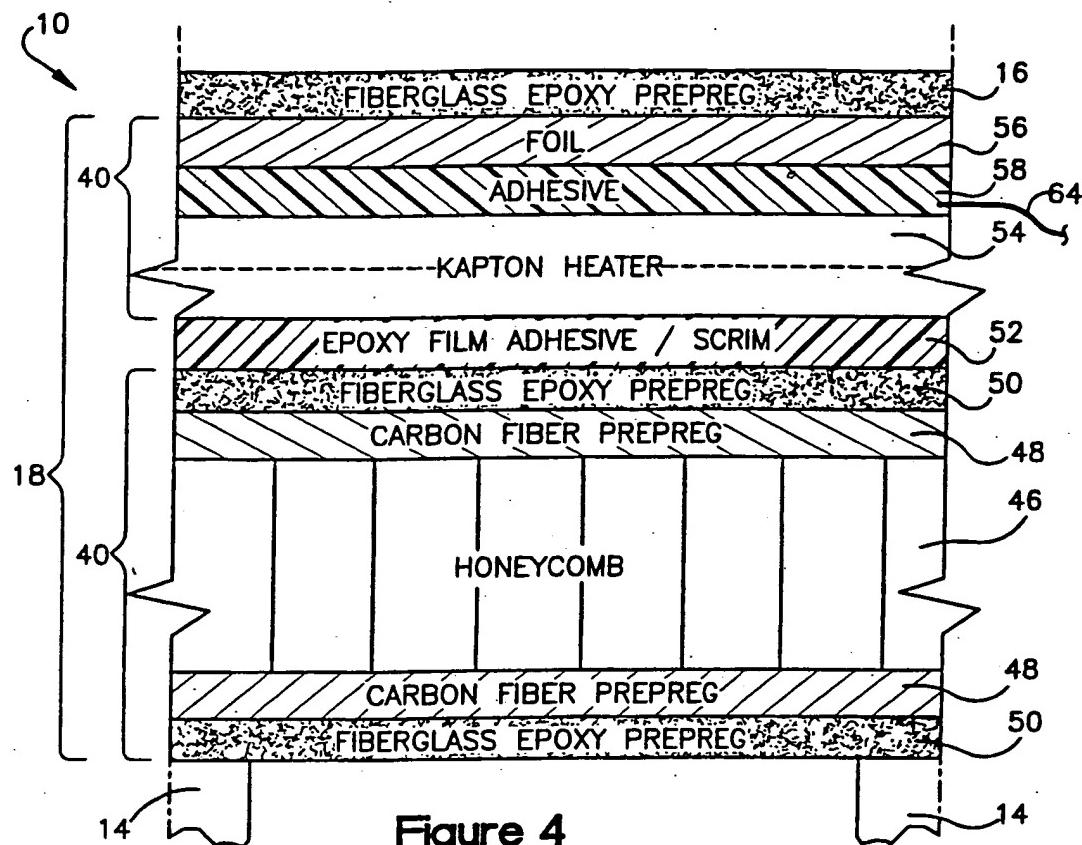


Figure 4

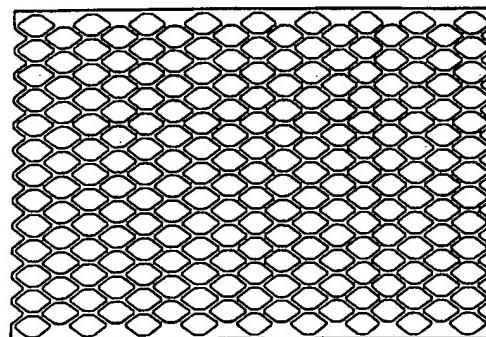


Figure 5

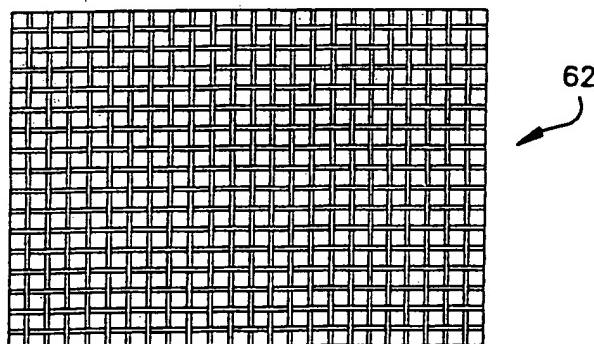


Figure 6

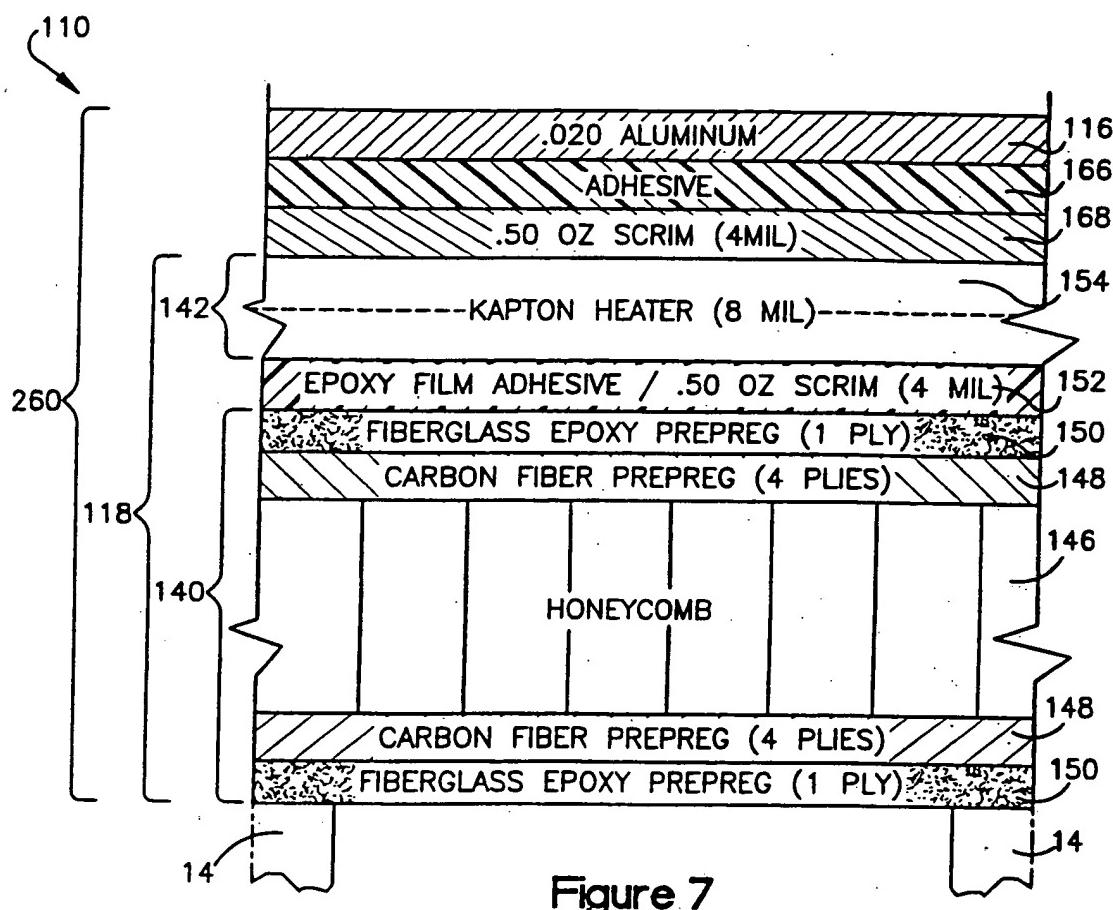


Figure 7

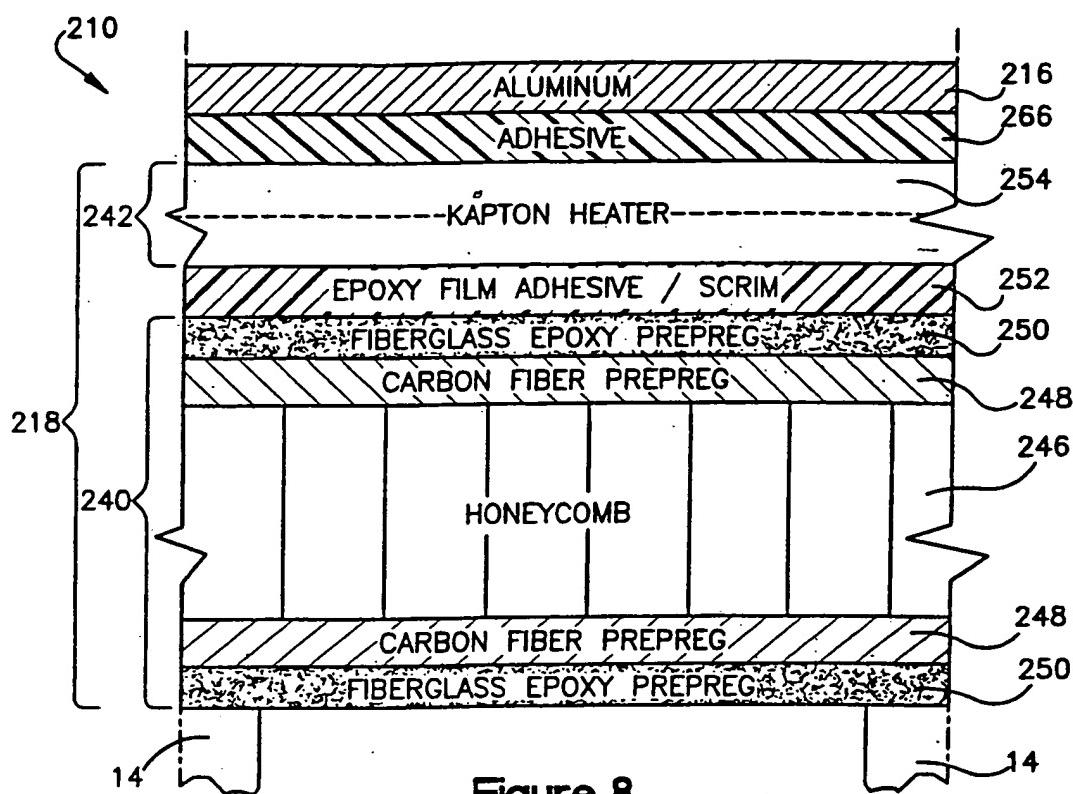


Figure 8

Figure 9A

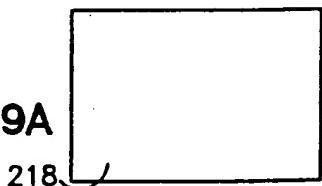


Figure 9B

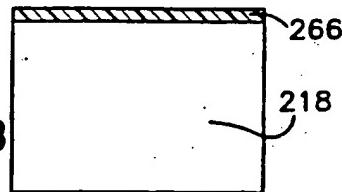


Figure 9C

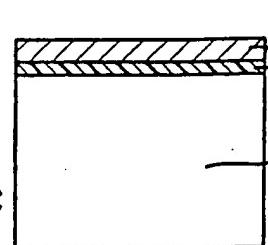


Figure 9D

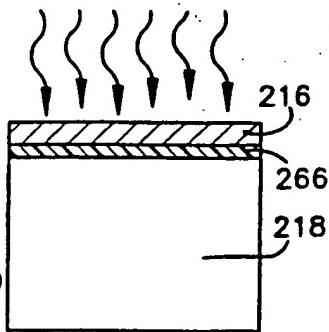


Figure 9E

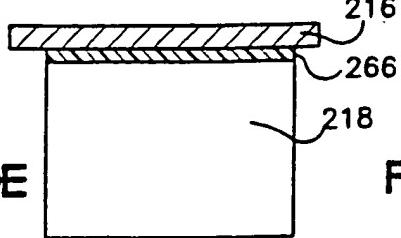
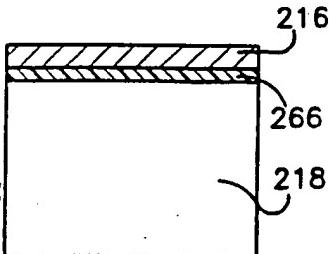


Figure 9F



INTERNATIONAL SEARCH REPORT

Int'l. Appl. No
PCT/US 00/24874

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B64C1/18 B64C1/40 F24D13/02 B64D13/08 H05B3/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B64C F24D B64D H05B B32B C09J B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 697 728 A (STIRZENBECHER GEORGE H) 10 October 1972 (1972-10-10)	1, 3-7, 13, 17-20, 25, 26, 28, 43, 44, 46
Y	abstract	2, 10-12, 14, 15, 27, 29-34, 45, 47
A	column 3, line 12 - line 21 column 3, line 41 - column 4, line 3 column 4, line 26 - column 5, line 37 column 6, line 10 - line 42 column 8, line 13 - line 42 figure 1	8, 14, 22, 27, 45, 47

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Date of the actual completion of the international search

6 December 2000

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Name and mailing address of the ISA

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NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl.
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X	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 05, 30 June 1995 (1995-06-30) & JP 07 032518 A (DAIRIN SHOJI:KK), 3 February 1995 (1995-02-03) abstract	5, 43, 44, 46
A		1, 18, 19
Y	US 5 851 336 A (FRYE BRADLEY A ET AL) 22 December 1998 (1998-12-22)	2, 14, 15, 27, 29-34, 45, 47
A	abstract column 4, line 38 - line 63 column 7, line 29 - line 39 column 7, line 50 -column 9, line 15 figure 1	37-42
Y	US 4 291 079 A (HOM FELIX) 22 September 1981 (1981-09-22) abstract; figures 1,2	10-12
A	US 4 598 007 A (KOURTIDES DEMETRIUS A ET AL) 1 July 1986 (1986-07-01) abstract column 9, line 14 - line 39 figure 1	37-42
E	EP 1 046 576 A (DAIMLER CHRYSLER AEROSPACE) 25 October 2000 (2000-10-25) the whole document	1-7, 13-15, 18-20, 29-33, 43, 44, 46

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inten	Application No
PCT/US 00/24874	

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
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